Improve Hurricane Intensity Forecast by Machine Learning of NASA Satellite Data

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Poster #11

Objective:

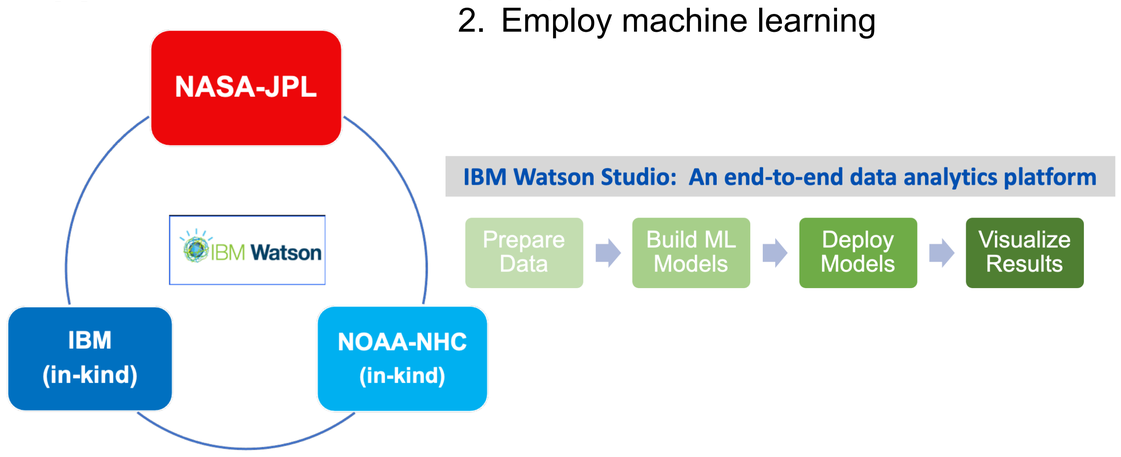
Employ machine learning (ML) techniques and apply NASA satellite observations to improve tropical cyclone (TC) intensity forecast, especially rapid intensification (RI) forecast

Motivation:

- TC intensity forecast has been a challenge for decades
- RI, defined as hurricane maximum sustained wind speed change greater than 30 knots within 24 hours, is particularly difficult to predict. Improving RI forecast accuracy is the top priority of the National Hurricane Center (NHC).
- The NHC's probability of detection (POD) for RI in the Atlantic basin is < 40% and the false alarm ratio (FAR) is > 60% (Kaplan et al. 2015).

Approach:

1. Augment predictors for RI
2. Employ machine learning



Identifying New Predictors for RI

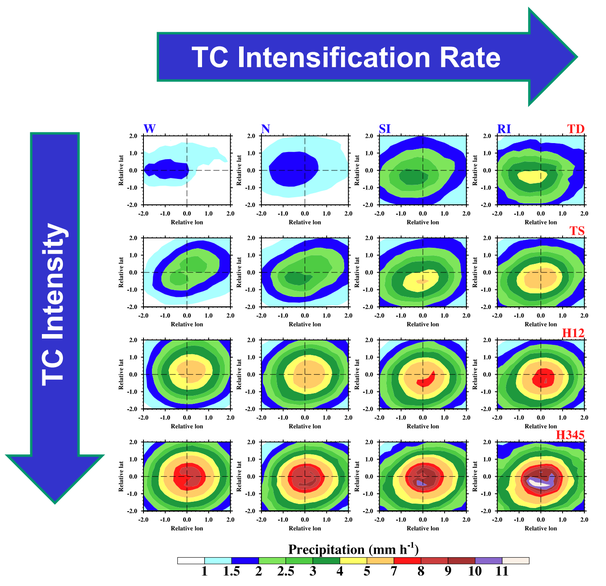


Fig. 1. Composite maps of TRMM precipitation rate in storm-centered coordinate for four TC intensity and four TC Intensification rate groups.

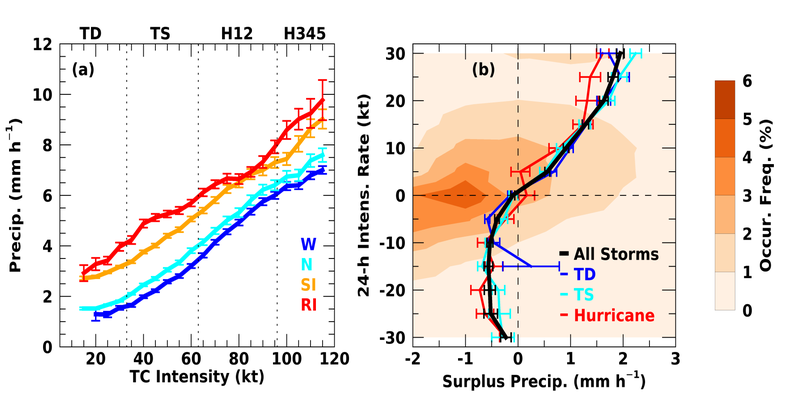


Fig. 2. (a) Composite inner-core precipitation rate as a function of TC intensity for four intensification groups. (b) TC future 24-hr intensity change (DV24) as a function of surplus precipitation for all TCs and three TC intensity groups.

Surplus Precipitation $S = P - P_N$

❖ **Inner-core TC precipitation rate, ice water content and outflow temperature bear simple relations with TC intensity change and thus can serve as predictors for RI.**

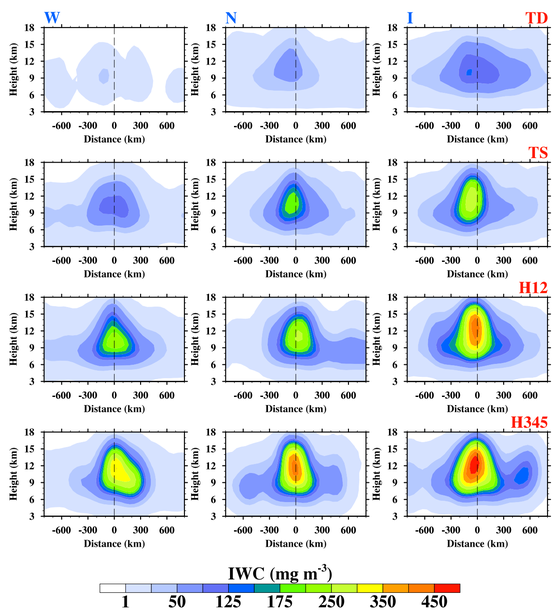


Fig. 3. Composite ice water content profiles in storm-centered coordinate for four TC intensity and three TC intensification rate groups.

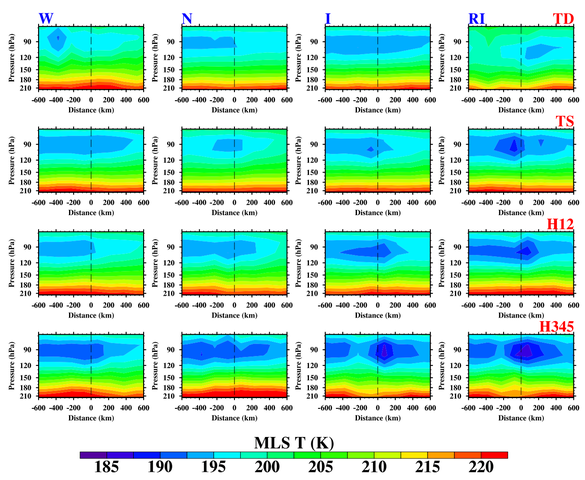


Fig. 4. Composite outflow temperature in storm-centered coordinate for four TC intensity and four TC intensification rate groups.

Building a Machine Learning Model

- North Atlantic Basin
  - Training: 2680 cases (1998-2008), Test: 1228 cases (2009-2014)
- Eastern North Pacific Basin
  - Training: 2428 cases (1998-2008), Test: 1349 cases (2009-2014)

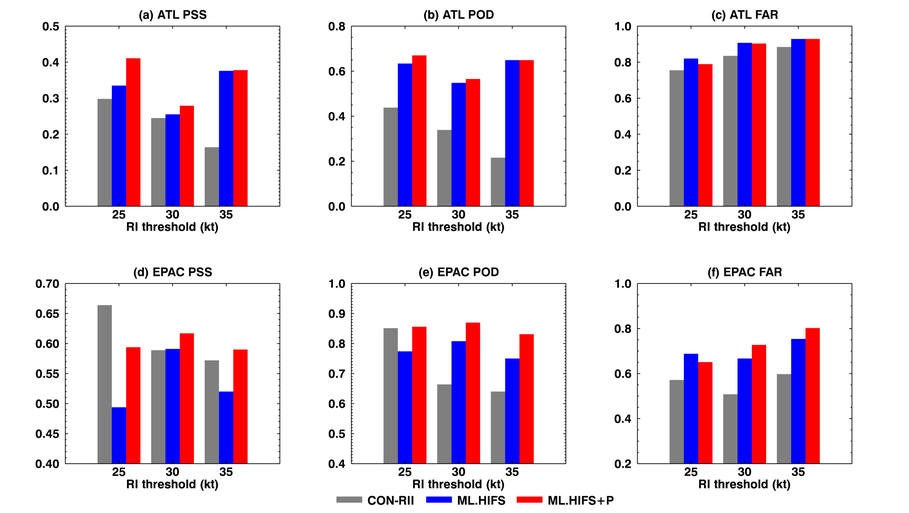


Fig. 5. Predictive skill for RI in North Atlantic (top) and Eastern North Pacific (bottom) for three RI thresholds (DV24 ≥ 25, 30 and 35 kt). (a) and (d) the Peirce Skill Score (PSS), (b) and (e) POD, (c) and (f) FAR. The grey bars are the operational RI consensus forecast scores and the blue (red) bars are the machine learning model using the SHIPS RII predictors without (with) the surplus precipitation from TRMM.

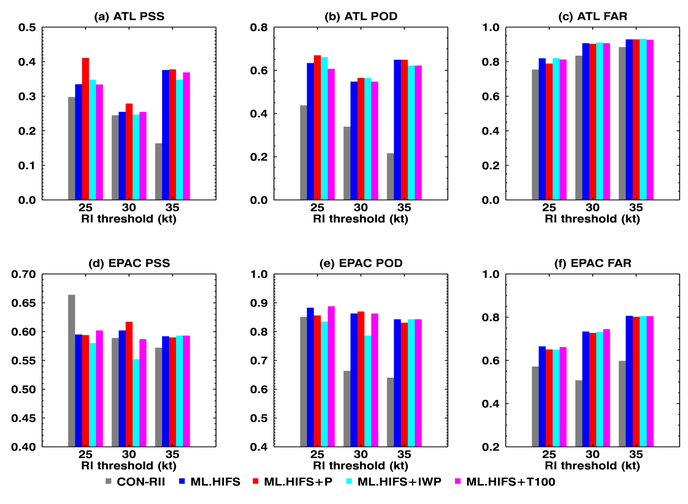


Fig. 6. The forecast scores for RI using the SHIPS RII predictors only, and with the addition of TRMM precipitation (P), MERRA-2 ice water path (IWP) and 100 hPa temperature (T100) as predictors. The grey bars represent the NHC operational RI consensus results.

Conclusions:

- Tropical cyclone intensity change is approximately linearly correlated with surplus inner-core precipitation, ice water path and outflow temperature.
- The JPL-ML model significantly outperforms the NHC operational RI consensus forecast results. Our probability of detection for RI in the Atlantic is 40%, 60% and 200% higher than the NHC operational model while the false alarm ratio is only 4%, 7% and 6% higher for 25-, 30- and 35-kt RI thresholds, respectively.

References:

Su, H., Wu, L., Jiang, J. H., Pai, R., Liu, A., Zhai, A. J., et al., Applying satellite observations of tropical cyclone internal structures to rapid intensification forecast with machine learning. Geophysical Research Letters, 47, e2020GL089102, http://dx.doi.org/10.1029/2020GL089102 (2020).

Kaplan, J. et al., Evaluating environmental impacts on tropical cyclone rapid intensification predictability utilizing statistical models, Weather Forecast. 30 1374–96, https:// doi.org/10.1175/WAF-D-15-0032.1 (2015).

Acknowledgements:

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